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CRUISE RESULTS

Chartered Vessel Cruises No. 2000-1
F/V *Hickory Wind*, F/V *Hazel Lorraine*

Halibut Excluders for Trawl Cod Fishing with
Results of a related Exempted Fishery conducted with
The Groundfish Forum and the At-Sea Processors Association

Two Alaska Fisheries Science Center (AFSC) cruises were conducted to test for differences between Pacific halibut (*Hippoglossus stenolepis*) and Pacific cod (*Gadus macrocephalus*) that could be used to exclude halibut from trawl catches, while retaining cod. An excluder based on these observations was then tested in an industry-sponsored exempted fishery. Halibut bycatch can be a limiting factor on the cod fisheries of the Gulf of Alaska and Bering Sea. Previous cooperative efforts have demonstrated the effectiveness of excluder devices for some sole fisheries and it was recognized that a similar tool for the cod fisheries, while technically challenging, could be very useful in reducing halibut bycatch.

In early 2000, two fishing industry organizations, The Groundfish Forum and the At-Sea Processors Association, proposed an exempted fishery to test a halibut excluder for use in trawl fisheries for cod. They asked Craig Rose of the Resource Assessment and Conservation Engineering (RACE) Division of the AFSC to develop a device for testing, starting with the knowledge developed in the sole fishery project and gained from discussions with captains from the trawl fleet. Initial separation concepts, based on morphometric differences and previous behavior observations, were tested during two AFSC cruises aboard the chartered vessels F/V *Hickory Wind* and F/V *Hazel Lorraine* in June and August 2000. Observations made during those cruises allowed those concepts to be refined and extended. The excluder system developed during these two cruises was tested in September 2000, during the exempted fishery aboard the F/V *Legacy*.

During these tests, an auxiliary net was used to capture the fish which exited the trawl, holding them separately from those retained in the trawl’s main codend. This allowed quantitative analysis of the resulting selection of the species and sizes of fish being retained and excluded. An infrared video system was

used to observe variations in fish reactions to the components of the excluder.

AREA OF OPERATIONS AND ITINERARY

All of the trawling in this project was conducted east and south of Kodiak and Afognak Islands in Alaska. Trawl locations were selected for likelihood of encountering Pacific cod schools with some Pacific halibut present.

F/V *Hickory Wind*

June 17	Loaded vessel
June 18-19, 23-28	Field operations near Kodiak Island
June 29	Unloaded vessel

F/V *Hazel Lorraine*

August 11	Loaded vessel
August 12-16	Field operations near Kodiak Island
August 17	Unloaded vessel

F/V *Legacy* - Exempted Fishery sponsored by The Groundfish Forum and the At-Sea Processors Association

September 16	Loaded vessel
September 17-23	Field operations near Kodiak Island
September 23	Unloaded vessel

OBJECTIVES

To develop and test trawl modifications to exclude halibut from the catch, while retaining Pacific cod, this project was designed to measure and assess:

1. the behaviors of cod and halibut as they encountered excluder components;

2. the escape rate for Pacific halibut;

3. the escape rate for Pacific cod;

4. size selectivity for both species; and

5. handling characteristics and durability of the designs for each excluder configuration tested.

METHODS

During each of the cruises, the vessels used trawls and rigging which they used when commercially fishing for Pacific cod. No alterations were made to the forward part of the net, the sweeps or the doors. Excluders were installed in or immediately ahead of the untapered intermediate section of the trawl. A recapture net was also installed to retain all fish moving out of the escape openings of the excluder. Care was taken in rigging this net to keep it from masking the escape openings, or being clearly visible from those openings, so as not to affect fish behavior.

Towing speeds varied between 3 and 4 knots and the ship's positions, based on GPS (Global Positioning System) fixes, were recorded at one minute intervals throughout each tow, except during the exempted fishery when only starting and ending positions were recorded. Temperature, light level and depth were recorded with a data logging sensor attached to the top of the trawl.

Catches from the main and recapture codends were sampled separately. Whenever feasible, the length of each halibut was measured. If it was necessary to subsample fish, a systematic sample was obtained by measuring every n^{th} fish, where n was an integer that would result in a sample of 100 or more fish. Individual halibut weights were determined from a length/weight table.

Sampling of cod was similar to that for halibut during the first two cruises, except that, for very large catches, baskets were used as the sampling unit instead of individual fish. Baskets of cod were weighed to obtain the total catch weight. During the exempted fishery, basket samples of the catch were taken from a conveyor belt in the ship's factory and the cod were separated from the other species. The number of baskets sampled was adjusted get a sample of at least 100 cod. Lengths of all sampled cod were measured. Samples were taken at regular intervals throughout the catch. The entire catch, before sampling, was weighed as it passed across a flow scale. Total

cod weight in each haul was estimated by extrapolating sample weight to full catch weight.

Intensified CCD cameras (ICCD) with high sensitivity in the

infrared range were used with infrared LED illuminators to observe fish behavior. While the rapid absorption of infrared light by water limited the range of this combination, the insensitivity of fish vision to infrared light made observation possible while providing minimal illumination for the subject fish. Batteries and a video recorder in an underwater housing were connected to fixed camera and light mountings within the net to provide power and record the video output. These systems were started when the trawl was launched and operated throughout the trawl tow. Tapes were reviewed after each tow to assess the configuration of the excluder components and to assess fish their effects on fish behavior.

Excluder Designs and Results

F/V *Hickory Wind*

Halibut excluders developed for the sole fishery consisted of sloped panels across the intermediate section with holes (rigid squares or mesh) of a size that allowed the sole to pass through while directing the larger halibut to an escape opening at the top or bottom of the net. In some of the designs, there was a wide, compressed horizontal tunnel along the top (or bottom) of the net between the end of the slope and the escape opening. Large meshes between this tunnel and the main body of the net provided sole with more opportunities to remain in the catch.

The main challenge in applying this concept to cod fisheries was that cod are much more similar in size and swimming ability to halibut than are sole. Thus, a square hole or mesh large enough to allow all cod to pass would only exclude the very largest halibut. The different body shapes of these fish were considered a characteristic that could be exploited for separation. When alternate hole shapes were considered, it was noted that rigid circular holes, sized for the largest cod, had the best chance of excluding smaller halibut. Therefore, the excluders for the first cruise were constructed with rigid circular holes in the selection panels.

Five panels for the slope and the inside wall of the tunnel were constructed of welded stainless steel rings (0.64 cm (0.25 inch) diameter stock) linked by welded wire (0.32 cm (0.125 inch)) loops. The 21.5 cm (8.5 inch) inside diameter (ID) rings were linked in a hexagonal array, with rows of 7 rings alternated with offset rows of six rings. These linked rings were secured inside 107 cm (42inch) long by 163 cm (64 inch) wide fiberglass frames (1.3 cm (0.5 inch) diameter solid rods) to prevent tangling and

facilitate attachment to the net. Two similar panels of 19 cm (7.5 inch) ID rings, alternating rows of 8 and 7, were also constructed. Finally, a rigid aluminum frame, with a rectangular array of 8 by 9 circular holes (20 cm diameter) was also available for testing. To make this frame more comparable to the flexible frames, 19 cm steel rings were affixed inside of each of these holes.

The 21.5 cm rings were tested first, installed with 3 panels forming a constant slope from the top to the bottom of the intermediate section and two panels forming the top of a tunnel against the bottom panel of the net. Three tows were made in that configuration, followed by two tows with the horizontal tunnel eliminated.

While all of the tows with 21.5 cm rings retained more than 95% of the cod, they retained a similar percentage of the halibut (Figure 1). On only one tow was a significant proportion of halibut excluded (47%). That tow was unique in that half of the halibut encountered were longer than 80 cm. On all other tows, fish of that size made up less than 1% of the halibut. The relatively small halibut (averaging 1.6 kg) captured with the cod (averaging 3.1 kg) made separation with this ring size ineffective.

The remaining tows were made with 19 cm rings, six with the flexible grates forming the slope and four with the rigid grate. No tunnel rings were used with either. None of these tows achieved useful selection. The general pattern was that more cod and halibut were excluded with the smaller rings, but that both species were excluded at similar rates (Figure 1).

Underwater video observations of fish encountering the holes showed that even though many fish did not pass through at the first encounter, both cod and halibut could pass the grates at relatively high rates. Skates which encountered the grates would usually become entrained, blocking a portion of the grate for the remainder of the tow. On the final tow, a combination of skates and a very high catch rate of cod resulted in the rigid grate becoming completely blocked, with the subsequent catch accumulating ahead of it.

The principal conclusions from the *Hickory Wind* cruise were:

1. While this type of excluder could be effective for larger halibut (>80 cm in length), it would not be useful when most

of the halibut were smaller (< 70 cm). Alternative methods would have to be developed for smaller halibut.

2. A method for preventing skates from blocking the grates could result in better operation.

F/V *Hazel Lorraine* Cruise No. 2000-1

To address problems related to skates and small halibut, two devices were added to the trawl for the next cruise. A large mesh (20 by 20 cm) panel, was installed ahead of the ring excluder to deflect skates before they reached the ring slope (Figure 2). This panel was cut as square mesh, 40 bars long and 12 bars across the front edge, tapering to 10 bars across the aft edge. The front edge of the panel was installed between the center of the side panels of the intermediate and the sides were secured to a descending bar of those panels until it reached the lower ribline. From that point aft, the skate panel was affixed to the edges of the bottom panel. Thus, approximately half of the skate panel formed a descending slope that blocked the lower half of the net, while the aft portion and the bottom of the net formed a narrow tunnel that was closed off where the aft edge of the skate panel was secured to the bottom panel of the net. A slot in the bottom panel, secured shut during towing, allowed the fish that accumulated in that bag to be released as the net was brought aboard.

To allow the escape of small halibut, the difference in body shapes between cod and halibut was again exploited. Because of their wide flat body shape, it was expected that even medium size halibut could pass through a horizontal slot that would accommodate only the smallest cod. Estimates based on published cod girth data and a few measurements of halibut thickness indicated that a slot height of 9.2 cm (3.6 inches) would allow halibut up to 90 cm through, while retaining cod less than 50 cm long. (We later found these estimates to be based on an incorrect assumption, as described below.) Four panels, each with a 3 by 14 array of 9.2 by 36 cm horizontal slots, were constructed of fiberglass rods inserted through crosspieces of rubber hosing (Figure 2). These were installed in an open section (no intermediate mesh) behind the ring excluder so that fish passing through the slots escaped and those that did not pass through were guided to the codend. The slot panels were installed vertically on the sides of the net. The front two panels angled toward each other from the spread of the riblines to a spacing of 51 cm (20 inches) apart (Figure 2). The aft two panels formed a 51 cm wide channel, leading back toward the codend. The aft

opening of this channel was obstructed by an aluminum frame, supporting flexible, plastic ‘fingers’, which fish had to bend to pass. Mesh was installed between the top and bottom edges of the slot panels to prevent escape upward or downward.

The combination of ring and slot excluders achieved a better selection between species, retaining approximately 70% of the cod, but only 20-25% of the halibut (Figure 3). After several tows, the frame with the flexible fingers was damaged and replaced with a broad grid of stretch cords (bungees). This resulted in a decrease in cod retention and an increase in variability, for cod and halibut. The escape of cod was notably greater in an area (Bungee (E) in Fig. 3) where the cod were mostly smaller. For the final tows, the ring excluder was removed. This resulted in an increase in the retention of halibut to 40-65%, with little apparent improvement in cod retention.

Video observations of the slot section showed why more cod were escaping than had been expected. When cod encountered the slots in an upright position, only very small cod would pass through. However, when crowding caused vigorous attempts to pass through the slots, cod turned on their sides and compressed their heads between the bars. In this way, much larger cod were able to pass through the slots. It was clear that smaller slots would have to be used to reduce cod loss. To estimate a more effective slot width, compressed head width measurements were made for both cod and halibut.

The skate excluder was effective at preventing large skates from reaching and blocking the selection panels. Large skates were retained between the aft edge of the panels and the bottom of the intermediate.

F/V *Legacy* - Exempted Fishery

The excluder system tested during the exempted fishery was identical to that used during the Hazel Lorraine cruise, except that:

1. the slots in the slot excluder were reduced to 7 cm (2.75 inches) in width (20 slots across instead of 14);

2. the flexible fingers were installed at both the forward and aft ends of the narrow portion of the slot excluder; and (Instead of being mounted within and

aluminum frame, these fingers were affixed outward from fiberglass rods that were installed vertically down the center of the opening.)

3. the forward portion of the ring panel was mounted within a 229 cm (90 inch) diameter aluminum ring, instead of just being tied to the sides of the intermediate. (This frame was one that the *Legacy* used for its halibut excluders in sole fisheries.)

The initial tows resulted in halibut retentions of approximately 20%, about half of the cod were also escaping (Figure 4). Cod size data indicated that even large fish were escaping, so an adjustment was made to the ring excluder. To make it harder for fish to pass through the tunnel to the escape opening, a fiberglass rod was installed under the bottom panel of the intermediate in the tunnel section. This closed the tunnel down to a thin slot between this rod and the rods of the ring frames. While this modification did not affect halibut retention, it did improve cod retention.

A second constricting rod was then installed aft of the first to further hamper escape and encourage fish to pass upward through the tunnel's rings. This resulted in cod retention values between 75 and 86% with halibut retention still around 20%.

The final tows were made with the ring excluder removed, to see how the slot excluder performed alone. While the cod retention was excellent (97-99%), halibut retention rose considerably.

Conclusions

Through this series of experiments, an excluder system which retains cod while excluding halibut was developed and demonstrated. This system includes a mesh panel to exclude skates, an excluder based on rigid rings to exclude large halibut and an excluder based on rigid slots to exclude small halibut. The effectiveness of these elements was dependent on the size of the cod and halibut entering the net. Selected adjustments of the configuration and dimensions of excluder openings improved selectivity.

SCIENTIFIC PERSONNEL

F/V *Hickory Wind*

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AFSC - Alaska Fisheries Science Center, NMFS
ODFW - Oregon Department of Fish and Game
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